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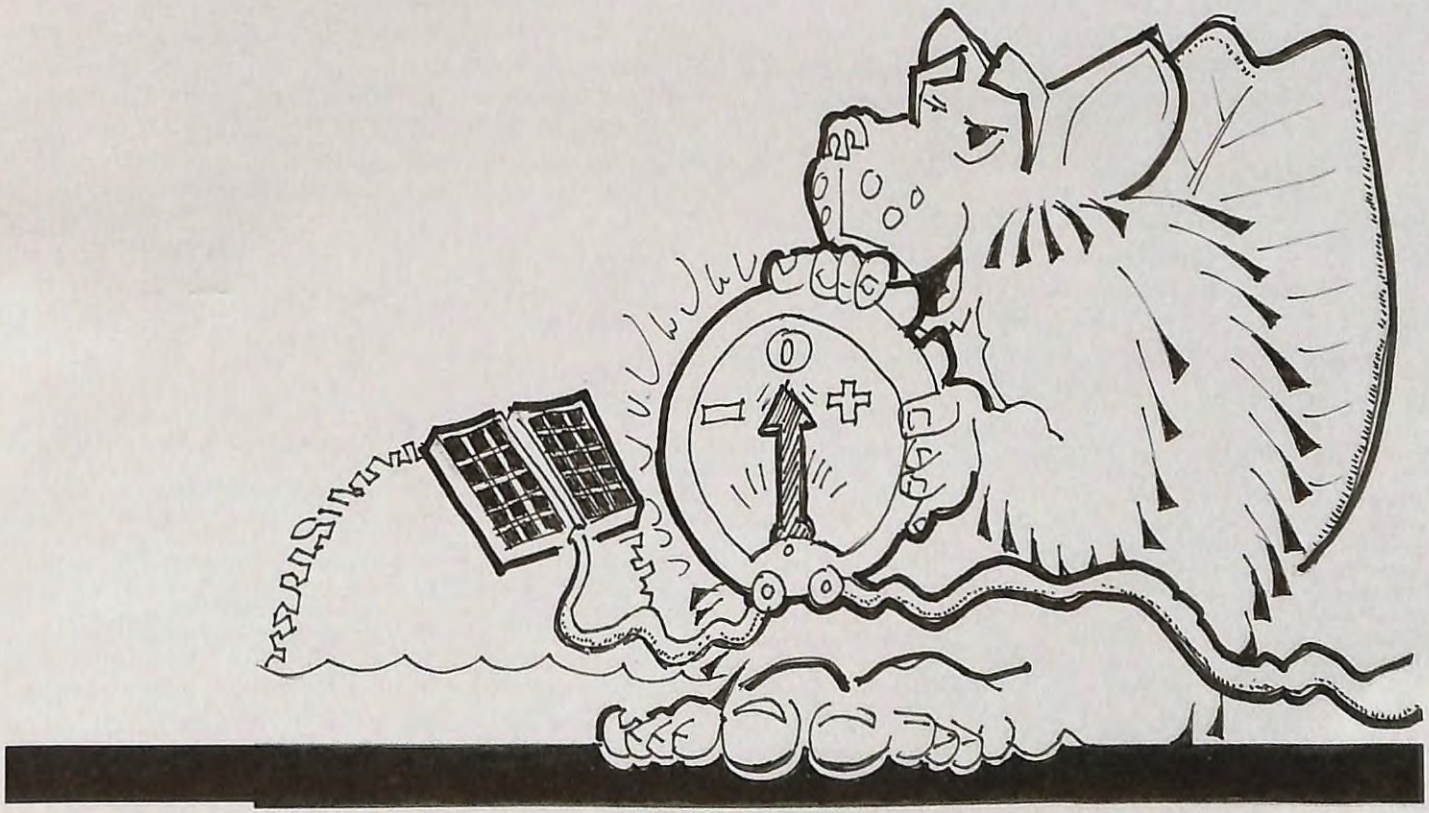
Net-Zero Housing



From the Editor . . .

Sometimes I wonder what has happened to our sense of innovation and optimism about the future, our enthusiasm for learning and applying new ideas and for making the world a better place. It seems that we are being increasingly driven by small minds with limited vision.

A number of years ago, builders in Alberta spearheaded development of the Built-Green program. It was an industry-driven voluntary program to promote "green" building practices to reduce the impact that building has on the environment.

Built-Green built on the work of the R-2000, EnerGuide and green building programs in the US. It was developed as a stepped structure to help builders improve their housing product, rather than a single pass-fail criteria as required for R-2000 or Passive House compliance. As builders understand what it takes to upgrade their product, Built-Green permits them to progress, starting from a Bronze level, which is only a bit better than standard practice of the day, to Silver, Gold and Platinum levels – each level becoming more stringent.

Each level requires a minimum number of points from an extensive checklist that covers not only materials and methods, resource and waste management, water conservation, mechanical and indoor air quality issues, but also business practices in addition to energy efficiency. At the outset, the indications are, that along with competitive pressures, Built-Green helped raise the bar of housing, leading to higher performance houses in general.

From the outset, builder training was mandatory, as well as achieving a corresponding minimum EnerGuide rating for each step, in addition to attaining the points total required from the checklist.

Regrettably, something has been lost in the intervening years and it seems to be drifting into "greenwash" territory. A few years ago, the mandatory requirement for achieving a set EnerGuide rating for a given level was eliminated. Although there is still a requirement for an EnerGuide label, achieving a set rating for a given level is no longer a mandatory requirement. The rationale was that spec builders were finding it too difficult to be certain they could achieve a certain designation for their standard house models. The argument went along the lines that 'model A' placed on the opposite side of the street or around the corner might not meet the requirement unless expensive upgrades were made, although that could be avoided with some careful preplanning.

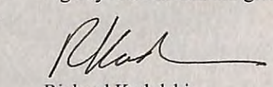
The latest change made recently removes the requirement for mandatory builder training. This ignores one of the strongest features of Built-Green, which was recognized by R-2000 years ago, that in order to have the capacity to deliver higher performance buildings, builders have to understand what is required to build an energy efficient high-performance house. It's not a simple matter of looking at the specs and attempting to apply them.

Homebuilders in BC have been concerned about this direction, and are pressing Built-Green to reconsider this change.

A major shortcoming of programs such as Passive House and LEED Canada for Homes is that they do not have mandatory builder training, but rely on consultants to do the hand-holding and instruction, which is a more cumbersome and expensive way to offer third-party certification.

If Built-Green continues on this path, simplifying its processes, it will be watering down the impact of the program just as it is becoming increasingly evident that we must press ahead to raise the bar and move the industry closer to net-zero energy – it is what is happening worldwide. It will be doing our industry a disservice.

Yes, there may be a struggle to achieve higher performance, but the attempt must be made. Otherwise, it matches the currents emerging out of certain sectors in Alberta that are denying any need to address global climate change issues.



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Net-Zero Housing: The Future of Housing

The characteristic of housing of the future is emerging – it clearly will be the net-zero energy house. A number of prototypes and demonstration projects have been built over the past few years. Their builders and other innovators are searching for ways to apply these principles to their regular projects.

Why Net-Zero? It is well understood that about 30 to 40% of total energy consumption is accounted for by buildings. Energy consumption of buildings is the major contributor to the environmental deterioration that we are seeing today, which is also a major contributor of greenhouse gases.

Zero net energy consumption by buildings is viewed as a means to reduce carbon emissions and reduce dependence on fossil fuels. In some parts of the world, the operative terms are zero carbon, rather than zero energy, but the end result is basically the same.

What exactly defines a net-zero house is subject to some interpretation. It is a home that produces as much energy on an annual basis as it uses. How this is calculated can vary depending on who's doing the analysis. Issues that come up include how one calculates the renewable energy contributions and whether off-site renewable energy generation is considered.

While we are focusing on housing, the same principles and issues apply to commercial and institutional buildings. In some respects, the non-residential sector could achieve net-zero performance more easily than the residential sector because of the more consistent patterns of use and occupancy and professional building operators to manage systems.

Most net-zero houses have super-insulated building envelopes with extremely low space heating needs, and high efficiency heating, ventilation and lighting technologies are used.

Energy is collected directly, through passive solar gains for space heating and with a combination of technologies to meet electrical and hot water needs.

Photovoltaic solar panels are the most often used for generation of electricity, especially as their price has come down with the large scale use of PV around the world today. Most houses are grid-connected and use the electrical grid for electrical energy storage. Depending on location of the house, other renewable energy sources may be taken advantage of, such as wind, micro-hydro or geothermal.

Net Zero House in Edmonton by Habitat Studio

The zero-energy goal is becoming more practical as the costs of alternative energy technologies decrease and the costs of traditional fossil fuels increase.

The challenge, especially in Canada, has been the low energy prices that consumers pay. The dirty secret of the energy industry is that these low prices are heavily subsidized, no matter the free-market rhetoric of industry and government. On the other hand, renewable energy technologies generally are not as heavily subsidized.

Initiatives such as Ontario's feed-in tariff for solar electricity are an exception.

The economic might of the conventional oil and gas industry adds pressure on the renewable energy options by playing the market pricing game. As interest in renewables starts ramping up, and viable options are developed, oil and gas prices recede. We saw that in the 1970s. The oil embargo by the oil-producing cartel, and the sudden price increases of conventional fossil fuels, generated much activity around conservation and alternative energy sources. Primarily due to significant efficiency increases in energy use, both for commercial and industrial applications and for buildings, total intensity of energy use moderated.

Today we are seeing echoes of that with the development of alternative sources of oil and gas. There is speculation in the oil industry that oil prices will fall as the US becomes an oil exporter, and unconventional oil and gas reserves are exploited. Of course, the continued growing exploitation of oil and gas resources world-wide ignores the most important fundamental issue of greenhouse gas emissions. We are creating a disastrous place for future generations.

The Net-Zero Energy Home Coalition

There is a wide range of approaches that can be used to achieve net-zero housing. The development of net zero-energy buildings has become possible not only through the progress in new energy and construction technologies and techniques, but also because of academic research, which has been collecting detailed energy performance data on traditional and demonstration buildings. This has provided performance parameters for computer models that can predict the efficiency of new design approaches.

Net-zero energy housing is being championed by the Net-Zero Energy Home (NZEH) Coalition. The coalition is a multi-stakeholder not-for-profit organization. Its members are North American champions of advanced energy efficient residential construction and building products, the utility sector, research and development, and manufacturing and deployment of on-site renewable energy technologies.

The purpose of the Coalition is to accelerate the market development of affordable net-zero energy homes. Their vision is that all new home construction should meet a net-zero energy standard by 2030. The Coalition's mission statement states that they will work with partners and stakeholders to move the residential building sector toward a net-zero energy target using all available tools.

The NZEH Coalition has embraced and actively supported the national EQuilibrium™ Sustainable Housing Demonstration Initiative led by Canada Mortgage and Housing Corporation (CMHC) and assisted by Natural Resources Canada's (NRCan's) energy analysis tools. EQuilibrium™ housing represents a significant step forward in reducing the energy consumption of Canada's housing sector, supporting the growing need for renewable energy solutions and helping Canada achieve a clean and healthy environment.

In October, coinciding with the Solar Decathlon in Irvine, California, the NZEH Coalition held their first-ever Net-Zero North American Leadership Summit. Leaders at the forefront of the NZEH movement converged, made valuable connections, and discussed how to accelerate the net-zero energy move across North America. Participants identified three critical areas for action:

- Collaboration – the need to share information, resources and best practices in meetings, online forums, and events such as the Summit Builder Exchange;
- Coordination – pooling resources for shared initiatives, such as an industry market awareness campaign and consumer behaviour study; and
- Collective Impact – using the power in numbers to educate and influence key stakeholders.

Participants expressed great urgency, as well as enthusiasm and energy, to move ideas into action. The Net-Zero Energy Home Coalition will serve as a backbone organization to drive and support these efforts.

One of the important activities of the coalition is a regular series of webinars touching on various topics.

It is important to point out that members and supporters of the NZEH Coalition are not just a small band of wild-eyed dreamers or fringe fanatics. A review of the membership directory will show a broad range of corporations and government agencies, builders, academics as well as consultants and individuals.

www.netzeroenergyhome.ca

Evolution of High Performance Housing – The Canadian Connection

In true Canadian fashion, we are beginning to import from overseas Canadian-developed technology as the latest and best, largely because we've not supported the initiative with the vigour it merits.

Beginning in Saskatchewan

The European ***Passive House*** standard has its roots in Canada. It grew out of the pioneering work done in Saskatchewan in the 1970s. It was initiated at a time when we were shifting our focus away from oil and gas to solar energy. It led to the construction of the Saskatchewan Conversation House in Regina in 1976.

Although the Saskatchewan Conservation house design was initiated as a solar demonstration project, the design team went back to first principles and looked at the whole house as a system. The team included members from the Saskatchewan Research Council, the Saskatchewan Housing Corporation, the Saskatchewan Power Corporation, the National Research Council's Division of Building Research, and the engineering faculties at the University of Regina and the University of Saskatchewan.

The low-energy home, designed for 85% less energy consumption than conventional construction at the time, demonstrated the principles of high performance housing. The solar system that was installed was eventually removed because there were challenges with the maintenance and its performance in the winter. In any case, the low-energy load of the house made the solar system largely redundant.

The impact of the Saskatchewan Conservation house was immense – thousands of people toured the house and it received international coverage. This project led directly to the R-2000 program. However, the R-2000 program was structured in a way that the building industry could implement high performance housing in a way that was achievable by industry.

R-2000 Program Launched

The R-2000 program was launched in 1982. It has always been a performance-based standard with a targeted energy consumption of at least 50% less than conventional practice. At the outset there were a number of prescriptive requirements, largely because of the limited number of material and equipment options on the market. These have now been dropped in the latest revision of the standard because of the market transformation in the past 20 years.

As house standards have increased, the differential between the R-2000 standard and conventional construction has decreased, from more than 50% more efficient to about 30% more efficient. With innovative builders wanting higher performance standards, and the growing move towards net-zero houses, CHBA approached NRCan several years ago with a proposal to update the R-2000 technical standard and move it closer towards net-zero ready.

R-2000 Standard Revisions (2012)

The latest revision of the R-2000 Standard now requires a calculated energy consumption less than 50% of the latest local energy code requirements or the National Building Code (whichever is most stringent). The recently created National Building Code energy standards set a standard of performance that is close to the older R-2000 performance requirement.

Saskatchewan Conservation House features

- Simple rectangular shape
- Window orientation favoured south facing windows
- High insulation levels:
- R-40 walls
- R-60 roof
- No basement; R-30 floor over crawlspace; R-30 crawlspace walls
- Airtight construction
- No conventional furnace
- Heat recovery ventilator (it was a site-built, do-it-yourself unit. Soon after, its principles were applied by manufacturers to factory-made units)
- Drain-water heat recovery
- Energy consumption was 85% less than it would have been if conservation techniques had not been applied.

Impact of R-2000

Although the number of certified R-2000 houses has not been large (there are about 14,000 certified R-2000 houses, and about 500 are certified each year) the program has had more of an impact on the housing industry than it has been given credit.

The performance requirements pressed industry to develop new materials, equipment and tools. The heat recovery ventilator we know and use today was a direct result. The improvements and innovation in heating and hot water equipment, as well as windows were also spurred on by the R-2000 requirements.

Personal computers were just in their infancy, but a software program (HOTCAN) that evolved into today's HOT2000, was written as the tool to be used when determining whether or not a given house specification would comply with the R-2000 energy targets. Many builders and designers are now routinely using HOT2000 to help optimize their designs, as well as to show compliance with R-2000 or energy code requirements.

Government involvement from the outset meant that extensive monitoring was undertaken – not just on one or two demonstration houses, but hundreds of houses. The monitoring was done to ensure that the houses would perform as intended and that there were no unintended consequences. The monitoring was not only technical but also included follow-up homeowner surveys. The results consistently showed that in general, R-2000 performed to expectation.

Mandatory builder training has been required by R-2000 from its inception. It introduced the industry to the *house-as-a-system* concept, and covers more than basic construction how-to fundamentals. This feature is one of the most important qualifying requirements, and one that has contributed to raising the bar for the home building industry, because even if a builder opted not to continue certifying R-2000 homes, he would take valuable lessons from the course that could be applied in all his work. To date, training is still a requirement for a builder to be able to certify a house.

The technology and construction approach was thus disseminated through the industry – even though numbers of certified homes may have been limited. It has led to the overall improvement of all construction in Canada. Even production builders were able to accommodate most, if not all, of the standard, and a few did certify homes.

Although R-2000 is focused on energy efficiency, there are also environmental, water conservation and indoor air quality requirements.

Although not taken up with the vigour we would like to see, the introduction of R-2000 helped move industry along. It has been seen as the leading edge, best-in-class standard of construction, but its champions have tended to be small custom builders with limited resources for marketing.

R-2000 on the World Stage

R-2000 has been acknowledged as a world-leading housing standard, and it was an important feature used by Canadian housing exporters. They were able to market energy-efficient, healthy, comfortable, affordable and environmentally friendly homes with the endorsement and certification provided by the government of Canada under the Super-E® program label.

The Super E® program was developed for international markets by Natural Resources Canada and was delivered in partnership with CMHC and Canada Wood. Together with the expertise of the National Research Council of Canada, these agencies worked closely with industry to accelerate the research and development of world-leading, energy efficient and healthy housing technologies. The British government's report on housing a few years ago endorsed Canada's energy-efficiency 'know-how' and recommended many of its 'tried and tested' best practices.

Super-E® certified homes have been built in Japan, the UK, Ireland, China, South Korea, and Iceland. This effort received the support of CMHC International, which provided critical technical support by analysing and interpreting regulations and opening doors.

The Canadian government still receives inquiries about housing and housing technology, which could aid Canadian manufacturers and builders interested in broadening their markets. Regrettably, support for the exporters was removed with the shutting down of CMHC International earlier this year. Canada Wood is still active promoting wood exports, but has expressed little support for Super-E housing.

International exposure with government support has several benefits. One is that it helps those in the export business, by opening doors and generating business for Canadians in markets where government sanction is important. It also helps Canadian industry domestically, as overseas research and innovations can be brought back to Canada and incorporated in our building stock.

The aeronautics and oil industries understand that very well, which is why they have ministers traveling the globe to help sell their wares. Unfortunately, the housing industry doesn't have the large integrated companies to press their case, and despite lip service, the current Canadian government does little to help the housing industry on the world stage.☼

Passive House Approach

The Passive House approach to construction is an ambitious response to global climate change and energy security issues. It was started in 1988 by Bo Adamson of Lund University, Sweden and Wolfgang Feist of the Institute for Housing and the Environment, in Germany, aided by financial assistance from the German state of Hesse.

The European Passive House standard focuses heavily on the energy performance of the building by setting an aggressive annual heating demand target of 15 kWh/m² per year through careful attention on the building envelope construction. The total primary energy (source energy for electricity) and consumption (primary energy for heating, hot water and electricity) must not be more than 120 kWh/m² per year. This yields energy performance savings of 80 – 90% compared to conventional construction.

The claim is that passive houses will provide year-round comfort in a cold or cool climate zone, with minimal heating/cooling energy use and no heating system. However, the calculations assume a winter indoor design temperature of 20 °C, while the Canadian design temperature is 21˚C.

Because energy intensity is the principle, it is a standard that can (and is) applied to commercial and institutional buildings as well as houses. Some European jurisdictions are already requiring public buildings to meet the Passive House energy consumption standard of 15 kWh/m² per year in their code requirements. Brussels is about to mandate that all new construction meet the Passive house standard.

Passive house requires the use of Passive House certified consultants to design or review the building design and do the computer modelling of the design using the Passive House design software (PHPP). Consultant training is an intensive five-day course, followed by a separate written exam. There is no builder or trades training requirement.

PHPP is based on European standards. This Excel-based modelling program has some 30 worksheets for calculating a building's heating, cooling and primary energy demand. It also identifies the potential for overheating in the warmer months. One challenge for North American users is that the PHPP only uses European values. Although the PHPP was developed specifically for Passive Houses, it is a design tool that can also be used for other building types, including retrofits of historical buildings.

The claim is that the PHPP has a high level of accuracy – that energy balances can be calculated to an accuracy of +/- 0.5kWh. Whether that level of accuracy is important for most cases is another discussion since we know that variations in weather and occupant behaviour will impact a building's performance significantly.

The level of detail required for the modelling, and the way calculations are done makes this more of an academic exercise than an industry responsive tool.

Efficient Building Shape

Because the amount of heat loss from any building envelope is proportional to its surface area, the building's surface area must be minimized to achieve exceptional energy efficiency. Passive House uses a 'Shape Factor' to assess buildings. This is a ratio of the building's surface area divided by its volume. Articulated building designs with dormers, jogs, exposed floors, heated garages etc. have higher shape factors, and will have higher heat losses, even if their floor areas are identical.

Solar Exposure

Passive solar gains form an important component of the heating requirements. In most regions of Canada high solar gains though south-facing glazing are potentially available and need to be utilized through appropriate design. At the same time, glazing on northern facades should be minimized. Passive house encourages south facing windows, while discouraging north facing windows.

Insulation

The insulation levels required for any building to achieve Passive House performance must be determined by modeling the building using the PHPP software and relevant climate data. In order to achieve Passive House performance, insulation levels will be much higher than conventional practice. Much effort is given to addressing thermal bridging details. In order to certify a Passive House, the designer must demonstrate that all parts of the building meet a strict thermal bridge criterion. This means that thick, highly insulated construction assemblies that include continuous insulation layers are a must.

Advanced Windows

Windows are the weakest thermal link in a building envelope, often representing 50% of all heat loss in a building. The quality of the windows is also critical to interior comfort, and the detailing must be such as to avoid cold spots. The better the window, the warmer the interior surface temperature of the glass will be. To achieve this in Canada, triple (and possibly quad) glazing is essential, using two low-e coatings and with argon or krypton gas fill, and insulated spacers. Window frames also need to be insulated.

Airtightness

Passive House requires very high levels of airtightness compared to conventional construction, at 0.6 air changes per hour. What sets the passive house testing apart is that the testing is done by both depressurizing and pressurizing the house. Consequently, conventional backdraft dampers on exhaust fans are perceived to compromise the air barrier.

The major problem with this is that the typical PH approach for kitchen-stove exhaust is the use of recirculating range hoods. However, this will have implications for indoor air quality as excess contaminants and steam are not removed and odours will linger in the house.

Regrettably, few people know that the recirculating range hoods rely on charcoal filters that have a small carbon charge and require frequent replacement if they are to perform odour removal. Most homeowners don't maintain their furnace filters let alone HRV filters, which typically need to be cleaned or replaced a couple of times per year. It is less likely that they will replace their range hood charcoal replacement filters which are not readily available at most hardware stores.

A discussion on the Passive House member's forum suggested the use of an HRV with a good grease filter as a stand-alone range hood, but that could create more safety hazards than it would solve, potentially be in conflict with Canadian codes, and not necessarily solve any problems, but cost a great deal.

Heating, Ventilation and Heat Recovery

Passive house claims that because of the low heat load of the highly insulated building envelope and solar heat gains, the houses do not need a heating system.

All Passive House buildings do require high-efficiency heat recovery ventilation systems. However, pre-heating of the ventilation air is relied on to pre-heat cold incoming air in order to keep the HRV frost-free and to provide the little bit of heat that may be needed during the coldest weather.☼

Solar Decathlon

The US Department of Energy Solar Decathlon challenges university teams to design, build, and operate solar-powered houses that are affordable, energy-efficient, and attractive. The winner of the competition is the team that best blends cost-effectiveness, consumer appeal, and design excellence with optimal energy production and maximum efficiency.

The first Solar Decathlon was held in 2002; the competition has since occurred every two years since 2005. The latest took place October 3–13, 2013 in Irvine, California. The idea has proven so successful, that now there are sanctioned Solar Decathlons in Europe and in Asia.

The Solar Decathlon serves several purposes. It:

- ☞Demonstrates to the public the opportunities presented by affordable homes that combine energy-efficient construction and appliances with renewable energy systems that are available today.
- ☞Provides student participants with unique training to help fill jobs in the clean energy economy.
- ☞Fosters collaboration among students from different academic disciplines, including engineering and architecture students, who otherwise may not work together until they enter the workplace.
- ☞Supports the US government's goal of transitioning to a clean energy economy.

The Solar Decathlon promotes an integrated, *house-as-a-system* approach to new construction, which differs from the traditional design/build process because the team has to consider the interactions of all building components and systems to create a more comfortable building, save energy, and reduce environmental impact. The Solar Decathlon encourages students to incorporate energy efficiency and clean energy into their future professional projects and personal lives.

Teams have to meet specific criteria to show their ability to design and build an innovative, entirely solar-powered house; raise additional funds; support the project through well-integrated curricula; and assemble a team to carry the project through to completion. In addition, a panel of professionals evaluate conceptual designs from proposers. Twenty teams are selected.

Like Olympic athletes, the Solar decathletes draw on all their strengths, including design and architecture, engineering and performance, and education and promotion. The teams rely on expertise from many disciplines as they must spend months fundraising, planning, designing, analyzing, and finally building and improving their houses.

Student teams in the 2013 U.S. competition included teams from the United States, Canada, Austria, and the Czech Republic. Over 10 days, they competed in 10 contests that gauged each house's performance, livability, and affordability, rewarding teams that build houses with estimated costs at or below $250,000.

The teams have to perform a variety of everyday tasks, including cooking, laundry, and washing dishes, to test the livability and energy use of their house. The winner of the overall competition is the team that best blends affordability, consumer appeal, and design excellence with optimal energy production and maximum efficiency.

Each of the Solar Decathlon's 10 contests is worth a maximum of 100 points, for a competition total of 1,000 points.

Teams can earn points in three ways:

1. Task completion. Teams complete household tasks such as cooking, washing dishes, and doing laundry.

2. Monitored performance. The houses perform to specified criteria, such as maintaining a comfortable (71°–76°F) indoor temperature range.

Contests based on task completion or monitored performance are called measured contests. These include Comfort Zone, Hot Water Heating, Appliance Performance, Home Entertainment and Energy Balance.

3. Jury evaluation. Jurors who are experts in their field (such as architecture, engineering, and communications) award points for features that cannot be measured (such as aesthetics and design inspiration). These include Architecture, Market Appeal, Engineering, Communications, and Affordability.

Some of the tens of thousands of visitors to the Solar Decathlon in Orange County, California.

The competition was the closest to date. Only 45 points out of a possible 1,000 separated the first place winner, Team Austria (951.9 points), from the tenth place, University of Southern California (906.2 points).

Team Ontario was 6th overall, but they topped the engineering contest. The jury felt that Team Ontario revealed a complete understanding of building science, a very good building envelope for the target climate, and excellent integration of passive and active strategies. They felt that this team best demonstrated design excellence with optimal energy production and maximum efficiency.

Team Ontario was judged 2nd in affordability (at $256,000), 1st for hot water heating and total energy balance (a tie with several others), and 4th in market appeal.

Team Ontario was a joint effort of Queen's University, Carleton University, and Algonquin College.

Team Alberta came in ninth overall with a score of 913.5 points. They placed 1st for hot water heating and total energy balance (a tie with several others); 4th in Market Appeal, and 4th in Affordability.☼

North side of Team Alberta's 'Borealis' house.

Canadian Home Builders' Association

Technical Research Committee News

High Performance Housing

CHBA has been a long-time supporter of the R-2000 Standard, which is recognized as a vehicle to pursue and promote leading edge, high performance housing technology. However, it has been noted that many builders are challenged by new high performance standards with the result that R-2000 sales have dipped in many regions.

Today's R-2000 Standard is still a world class, made in Canada building standard equal to any other in the world. Moreover, it is structured in a way that the building industry can readily access and deliver to homebuyers. The big challenge has been that, although the Federal government has maintained the standard with the support of CHBA, they have not provided marketing support to the standard, especially the latest upgrades.

The housing industry on its own doesn't have the required resources as it is composed of many small players. But if builders want to maintain their role as world leaders in the industry then it is essential that we find a way to make these houses more enticing and marketable to the consumer.

Recognizing the challenges, the TRC Management Committee has forwarded a request to the CHBA Board of Directors asking for the formation of a working group to look into the feasibility of forming a new committee or council to foster the development of high performance housing. This is, in part, in response to the Technology Roadmap on Sustainable Housing.

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.

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Vancouver Building Code Changes

The City of Vancouver has the unique authority to create their own bylaw, which generally follows the BC Building Code, which in turn is essentially the National Building Code of Canada. The City has recently adopted changes that will come into effect December 20, 2013 for all Part 3 energy standard provisions of the code and March 1, 2014 for the remaining provisions, which includes Part 9 buildings. The design and construction of houses will be especially impacted.

Significant changes for one- and two-family dwellings include:

- Improved energy efficiency for walls (effective R-21.8), attic roofs (R-50), windows max U value of 1.4 W/K·m^2 and skylights (max U value of 2.4 W/K·m^2)
- Higher efficiency hot water tanks (78%), boilers and furnaces (92%)
- Improved air-tightness: maximum air-tightness of 3.5 ACH.

CSA F280-12 Standard: Determining the Required Capacity of Residential Space Heating and Cooling Appliances

It is important that space heating and cooling systems have the proper output capacity. Too little or too much capacity can create a dangerous and uncomfortable living environment. The F280 Standard has been referenced in the building code for many years and provides guidelines for contractors and installers to calculate proper heating and cooling system energy capacity for appliances used in housing and small residential buildings. The previous standard, last revised in 1990, was badly out of date. Given the advances in heating system technology and changes in construction practices, it was overdue for an update. As with all standards, this update was carried out through a consensus-based public review process. The updated F-280-12 has a number of significant improvements.

The new F280 uses an updated air leakage model, and also takes into account ventilation air change, including direct entry of blower door test results, and whether the ventilation is balanced or unbalanced with or without heat recovery. The ventilation load is calculated at minimum flow rate, not maximum flow rate. The impact of this change alone is significant.

Using the old standard, the air leakage was assumed to between 7.2 to 13 air changes per hour at Pascals. This is not realistic with today's tighter houses that typically, on average, are in the range of 2 ACH to 4 ACH depending on the region. As a result, air infiltration and ventilation can represent 30 to 40% or more of the home's heating load, depending on how the building envelope is constructed. In addition, the old standard did not have an allowance for ventilation heat recovery, which is why the heating load is greatly over estimated with the old F-280.

The new standard also uses an updated basement heat loss model, and it has new window selection criteria.

The consequence of the change is significant. An analysis for a typical new Ontario house found that the heat loss calculated using the old standard was 69,420 BTU/hr of which 27,000 BTU's is due to air leakage. With the new standard, the heat load drops to 40,000 BTU/hr of which the ventilation with heat recovery accounts only for about 2000 BTU/hr. This not only means that a properly sized, small heating system needs to be installed, but for forced warm heating systems it allows the ductwork to be significantly downsized. It means that the HVAC systems in new houses need to be re-considered and designed differently to take into account these lower loads and new realities.

HRAI (Heating, Refrigeration and Air Conditioning Institute of Canada) is a national association that represents heating, ventilation, air conditioning and refrigeration (HVACR) manufacturers, wholesalers and contractors. They offer appropriate certification training programs for the heating trades. They have some 2,300 certified individuals that are qualified to design and install heating systems. All of these will have to be re-certified for the new F280 Standard. Regrettably, even though they have been involved with the CSA committee reviewing the standard, HRAI has not been preparing for the changes, so they don't feel they will be able to provide all the required update training until January 2016, and are pressing Ontario to delay implementation of F280.

Letter to the Editor

Re: The Importance of Planning Ahead

I just finished reading your above article in the Solplan Review No.171. As you make clear in the article, the issue of planning ahead is more often than not neglected in residential construction, resulting in excessive costs, needlessly frustrated trades people, under-performing buildings, and disappointed clients. You gotta love the photographs - my personal favourite is the first one, showing the framing for the rough window opening.

When I started as a novice carpenter/gofer in the trades in the early 1980s (raising, gutting and extensively renovating a Kitsilano triplex I owned with two others), it only took about three chaotic days on the job before I found myself thinking - "Gee, wouldn't it have been a good idea to have gathered everyone together before we started actually working on this and have some substantial Think and Do planning sessions? I wonder why nobody does that? "

Thanks again for the excellent article.

DR, Ottawa

Penticton Passive House

In the last issue of Solplan Review (no. 171) we highlighted a project in Penticton. The interesting feature is that the houses have identical floor plans, and similar household composition. Energy use monitoring will provide vital, real world information how energy efficient homes perform. Unfortunately, the wrong table appeared in the final, so we are reprinting the correct table this issue. The Passive House used concepts advocated by the Passive House program

Penticton Super Efficient Home Design features

R-2000 & ERS 88 houses

- Ceilings 12" structurally insulated panels
- Walls 8" structurally insulated panels
- Windows: triple glazed fiberglass
- Insulated concrete slab (R-12)
- HRV
- Heat pump
- LED lighting

Passive House Specs

- Ceilings 3 layers of R-22 batts.
- Walls double stud wall with 3 layers of Roxul R-22 batts plus 3" of Roxul's rigid insulation on the exterior.
- Windows: Quad glazed fiberglass (but larger south facing windows)
- Insulated concrete slab 10.5" EPS (R-44)
- European HRV
- LED lighting

Energy Answers

Rob Dumont

Can you suggest some rules for designing an Energy Efficient Home?

I am occasionally asked this question. Here are some rules of thumb I have developed over the years. Let's call them Dumont's Directives for a Decent Home in the era of global warming. They apply to the design of energy efficient detached houses in climates with a significant heating season (in other words, in almost all of Canada, the northern Part of the U.S., and other northern latitude locations)

1. Do not scrimp on design. Design fees are a small part of the overall cost of a new home. "The bitter taste of poor quality lingers much longer than the initial sweetness of a low price." So wrote John Stanhope. The quote applies to many purchases in life, and especially to house design. For most people, their largest single investment will be their house, and it pays to get the design right.

2. Choose a piece of land that has good solar access. The lot should have unobstructed access to the direct sun from about 8 am to 4 pm each day of the year. Watch out for solar obstructions from trees and adjacent buildings on the south, east and west sides of the lot. A wide lot facing south is definitely preferable to a narrow lot facing south. The wide lot allows for more south window and solar equipment to be installed.

3. Choose a shape for the house that is roughly rectangular with the long axis of the house running east and west. Avoid house shapes that have odd shapes such as L-shaped, T-shaped and U-shaped.

The L-, T- and U-shaped houses have more surface area and heat loss for the volume that they enclose compared with a rectangular shaped house plan.

4. Design for flexibility. A well designed house should last for centuries, and over that length of time many different uses will be made of the space in the home. As an example, provide a separate entrance to the basement of the house and design the basement space so that a kitchen, bathroom and living space can be incorporated at a later date. Another approach is to design an upper story of the house with a separate entrance and living space. Have the plumbing and electrical systems roughed in so that a separate suite can be readily developed at a later date. Make sure that all codes regarding spatial separations and safety are respected. The separate suite spaces should be developed so that a heating system can control the temperature in the suite independently of the temperature in the other living space.

6. If you want a garage and have the space on the property, a detached garage is preferable compared with an attached garage for safety reasons. People have died in homes with attached garages from car motors running and producing carbon monoxide which drifts into the living space. If you choose an attached garage, make sure than an excellent air barrier and fire barrier are incorporated between the garage and the living space. I almost lost an uncle whose car was accidentally left running in an attached garage. The carbon monoxide fumes from the car engine entered the house and nearly killed the occupants. Some years ago a lady in Alberta was killed by such an accident. The car in the garage was accidentally started by a remote starter.

Make sure that an electrical outlet (usually 220 volt) is placed in the garage so that electric cars can be charged once electric cars are more widely available.

7. Choose a contractor with experience in building energy efficient construction such as R-2000 houses and Energy Star houses. Make sure that the contractor has input on the design.

8. Choose windows with great care. On the south side, put windows with an area equal to about 8% of the floor area of the house. Windows that are hinged tend to have better air tightness than windows that slide. On the south side, choose windows with a solar heat gain factor of 0.55 or higher. To control unwanted solar gains on south windows in the cooling season, provide a roof overhang or awning that will shade the south windows. On the east and west sides, limit the window area, as windows in these orientations provide little passive solar heating in the heating season and yet contribute to overheating the house in the cooling season. Windows on the north side contribute little to useful space heating, and for this reason should be limited in area. On the east, west and north exposures, choose windows with a high R value.

9. Place inexpensive thermal mass in the home. A simple way to do this is to place scrap gypsum board in the hollow wall cavities of interior wood stud wall partitions.

10. Insulation levels

The author is a great believer in high insulation levels. His own home in Saskatoon was one of the best insulated houses in the world when it was built in 1992. The house has R-80 in the attic, R-60 in the above grade and basement walls, and R-35 in the basement floor. A home in Dillingham, Alaska – a cold, cloudy climate with high fuel prices – has even higher levels of insulation, with R-90 insulation in the walls, R140 in the attic, and R35 in the floor.

A recent paper by Proskiw and Parekh recommends the following insulation values for homes that strive to be net zero in annual energy consumption.

Vancouver	R60 to R80 attic insulation
Toronto	R80 attic insulation
Winnipeg	R80 attic insulation
Yellowknife	R80+ attic insulation

11. Air tightness and mechanical ventilation with heat recovery. Build tight and ventilate right. R-2000 builders know how to do both. Select a heat recovery ventilator that has a low electrical consumption.

12. Water efficiency.

The domestic hot water (DHW) load is usually the second largest energy load in houses after space heating. To reduce the DHW load, the following measures are recommended:

Low flow shower heads.
Energy Star clothes washer
Energy Star dishwasher
Drain water heat exchanger
Extra insulation on the water heater storage tank.
Locate the water heater close to the end uses in the kitchen and bathrooms.
High efficiency water heater.

13. High Efficiency Lighting. Compact fluorescent lamps (CFLs) and light emitting diode (LED) lamps are recommended.

14. Energy Star White Appliances (refrigerator, freezer, dishwasher, and clothes washer) are recommended. Look for Tier 3 Energy Star Appliances for the best efficiency.

15. Plan for the use of renewable energy technology devices such as solar water heaters and photovoltaic panels by orienting a roof surface toward the south at a tilt angle roughly equal to the latitude angle plus or minus 20 degrees at your geographic location. (Example: Saskatoon is at a latitude of 52 degrees North. A south-facing surface tilted between about 32 and 72 degrees from the horizontal will be close to the optimum for solar collection.) During the lifetime of the house, electricity generated by solar photovoltaic panels will very likely become less expensive than grid electricity. Plan for it.

16. Safety. If you have any combustion appliances in the home or if you have an attached garage, install a carbon monoxide sensor in the living space. Placing smoke detectors in each bedroom is also a good idea.

17. Durability. In coastal and higher rainfall areas, make sure that your walls are of a rain screen design. Don't buy the cheapest asphalt shingles for your roof. A lot of energy is required to replace short-lived building materials.

18. Reduce phantom energy loads (the electrical loads that draw power even though the device is nominally off) by having a separate electrical switch and outlet to control devices like your cable box, internet router, and TV.

In summary, a good house design should make use of strong energy conservation measures, use passive solar heating, and plan for the eventual use of more renewable energy devices such as photovoltaic panels and solar water heaters.

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For those that want Building Codes to be more stringent and raise the bar: remember that Building Codes set a standard that is the least one can legally build.
Codes do not set out best practice, nor do they prevent anyone from building to a higher standard.

Residential Electricity Use

We have much information about the amount of energy used for space heating and water heating. As buildings are becoming more efficient, they are drastically reducing the energy needed for space conditioning. However, electrical use in buildings remains significant.

Monitoring data for energy efficient homes has consistently shown that, despite more energy efficient building envelopes and the increased use of energy efficient lighting options and equipment, electrical use is greater than expected.

Determining how much electricity is actually used by the average household is a major challenge. Values used by codes, utilities, and programs such as R-2000 and EnerGuide are based on guesstimates that rely on long-term aggregate utility data accumulated over many years. There is also the commonly used assumption that the typical occupancy is 2 adults, 2 children 50% of the time. Natural Resources Canada's programs and the new energy code assign a fixed daily value for electrical base loads of 24 kWh/day. This is based on the assumption that 3.0 kWh/day is used for lighting, 14.0 kWh/day for appliances, 3.0 kWh/day for other uses and 4.0 kWh/day for exterior uses (exterior lights, block heaters, etc.).

In recent years there has been a lot of innovation and development in lighting, appliances and household energy management systems. All low energy initiatives and demonstration projects include the interior electrical systems. But the beneficial results are not consistent.

NRCan's next generation EnerGuide Rating System (ERS) has recognized the need to give credit when significant, quantifiable and verifiable measures are introduced to reduce the electrical consumption. As a result, NRCan undertook a research project in conjunction with a number of electrical utilities to survey household electrical use, with the object of developing a tool that could be used to survey household electrical use. The Residential Electricity Evaluation Protocol (REEP) is the tool that has been developed.

Testing included collecting data from a range of houses in all regions of Canada. Energy advisors collected data from a sample of more than 700 houses. It was found that the average number of occupants was 3 persons per house (2 adults, 0.8 school age and 0.2 pre-school children). On average there were 0.9 persons occupying the homes during the daytime on weekdays, and households are occupied about 95% of the time of the year, or about 49.5 weeks/year.

The evaluations collected data about lights, appliances, and other equipment in the house. It was found that in an average home, there are 57 lamps, more than 11 home-entertainment devices (i.e. TVs, home theatre systems, stereos, mini-stereos, DVD players, etc.), and more than 10 pieces of office equipment (computers, monitors, notebooks, cable/DSL modems, routers, printers, scanners, multi-function, etc.).

There are also about 13 other common devices such as small appliances, vacuum cleaners, clocks, etc. per household. Supplemental space-conditioning devices (ceiling fans, portable fans and heaters, dehumidifiers, humidifiers, etc.) account for another 2.6 devices per household. On average there are also 1.46 refrigerators and 0.8 freezers per household. Refrigerated wine cellars are less common, and on average there are less than 0.04 units per household.

Electrical use was correlated with utility bills. The average base-load consumption in the test samples was estimated at 6,919 kWh/year per household. This is equivalent to about 19 kWh per day of base-load usage.

Lighting energy use is 1,088 kWh per year, while small plug loads for home entertainment, office and communications, kitchen cleaning and grooming devices have an estimated electricity consumption of 2,252 kWh annually per household. Major appliances are estimated to use 2,674 kWh/year.

Home entertainment, including TVs, PVRs, video devices including games and photo frames, account for 909 kWh/year. Office and communications devices including computers, printers, modems, phones and other equipment account for 639 kWh/year, while small kitchen, cleaning and grooming appliances account for 704 kWh/year.

The average standby power use, i.e. the power used when appliances are plugged in but not being used, was estimated at about 740 kWh per year.

In some high efficiency net-zero homes, the house electrical system is designed to permit the reduction of standby electricity use by switching some circuits off when they are not being used – typically this is done for some entertainment and office and communications circuits. Information from a small sample of high efficiency homes showed that home entertainment use could be reduced to 341 kWh/year, and office and communications to 142 kWh/year.

The audit tool identified savings opportunities of 1,090 kWh per year by the replacement of equipment (use of higher efficiency appliances and switching from incandescent lamps), and 850 kWh per household from targeted behavioural changes. Behavioural changes identified include recycling extra refrigerators and freezers, using outdoor clothes lines for some clothes drying, using power bars to disconnect home entertainment and office equipment when not in use, and the use of timers on pool and spa pumps to reduce run times.

In order to recognize high efficiency homes that have taken measures to reduce their electrical base loads, the ERS may develop two electrical option packages that can be used: a mid-efficiency and a high- efficiency option. These packages would consider appliance and lighting efficiencies based on standard use assumptions, i.e. number of appliances, number of lights, hours of operation, etc.

Residential Electricity Usage Electricity Study for the EnerGuide Rating System by Strack Associates For: Sustainable Buildings & Communities, CANMET Energy Technology Centre, Natural Resources Canada

How many lamps in an average home? (A lighting fixture may have more than one lamp):

Average number is 57 lamps. Of these:
- 50% are incandescent lamps
- 33% are fluorescent 33%, and
- 17% are halogen and other

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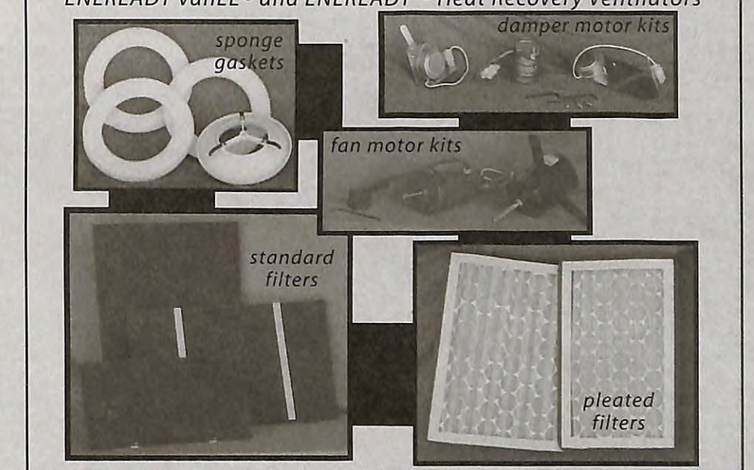

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